INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
16–834/2017/19–5–957–968
DOI: 10.17957/IJAB/15.0289
http://www.fspublishers.org

Review Article

An Overview of Plants with Acaricidal and Anthelmintic Properties

Muhammad Arfan Zaman[1*], Zafar Iqbal[2], Zia-ud-Din Sindhu[2], Rao Zahid Abbas[2] and Muhammad Fiaz Qamar[1]
[1]*Department of Pathobiology, College of Veterinary and Animal Sciences, Jhang, Pakistan*
[2]*Department of Parasitology, University of Agriculture, Faisalabad-38040, Pakistan*
[*]For Correspondence: arfan.zaman@uvas.edu.pk

Abstract

Geo-climatic and socio-economic conditions provide a favourable environment for parasitic population of livestock in Pakistan. Hard ticks (Ixodidae) and gastrointestinal nematodes pose most serious threats to livestock industry. Stackholders rely on synthetic drugs to control these parasites. Emergence of drug resistance in these parasites; however, has provoked interest in alternate of synthetic drugs. Testing of plants used in ethnoveterinary medicine for their antiparasitic activity employing standard procedures has been reported to be promising. Plants have been most frequently used for deworming purposes followed by as acaricides and insecticides; whereas, reports as to their antiprotozoal use are relatively less. Use of plants as antiparasitics is more frequent in developing countries having low accessability to the modern parasite control practices. Likewise, validation studies on the use of plants as antiparasitics have been more frequently carried out in the developing countries compared with those having livestock farming as commercial enterprise. This article presents an overview of the plants having acaricidal and anthelmintic activity, limitations as to the application of phytotherpay to control parasites and future prospects of the use of plants as antiparasitics. © 2017 Friends Science Publishers

Keywords: Anthelmintic; Acaricides; Antiparasitic; Ticks; Gastrointestinal nematodes; Plants

Introduction

Livestock play a crucial role in human food supplies and economy of Pakistan (Anonymous, 2014–2015). Parasitism is one of the most important constraints in optimum productivity of animals (Solcan *et al.*, 2015). Production losses due to parasitism may vary from one parasite to the other. In tick infestation, for example, losses may be due to loss of blood (Gabr, 2012), tick paralysis (Chand *et al*., 2016), transmission of different diseases (Duvallet and Boireau, 2015; Kmieciak *et al*., 2016), treatment costs (Gomes *et al*., 2016), etc. Likewise, gastrointestinal nematodes (GINs) may interfere with food intake and absorption adversely affecting animal productivity (Geurden *et al*., 2015; Ravinet *et al*., 2016).

Globally, tick infectations are recognized as most devastating ectoparasites (Godfrey and Randolph, 2011; Opara *et al*., 2016; Demessie and Derso, 2015) resulting in huge economic losses (Zheng *et al*., 2012; Asmaa *et al.*,2014; Chen *et al.*, 2014). Likewise, tick associated concerns as to their increasing prevalence, lowered animal productivity; their zoonotic potential and control have been considered as an important area for future research (Ashfaq *et al*., 2015; Jabbar *et al*., 2015; Zahid *et al*., 2016). Helminth infections are also ranked high among the factors leading to low production in animals throughout the world with varying prevalence depending on the climatic conditions, awareness of farmers on the recommended parasite control practices and accessibility to the animal health care (Khan *et al*., 2010b; Tasawar *et al*., 2010; Qamar *et al*., 2011; Borji *et al*., 2012; Katoch *et al*., 2012; Roeber *et al*., 2013; Singh *et al*., 2014; Bansal *et al*., 2015; Dalal *et al*., 2015; Lashari *et al*., 2015; Scala *et al*., 2015; Voigt *et al*., 2016).

Control of Parasitism

In general, control of ticks and GINs predominantly depends upon chemotherapy, even after the advancements in genetically, immunological and biotechnological methods (Sorge *et al*., 2015; McTier *et al*., 2016; Verma and Singh, 2016). Globally; however, use of synthetic drugs for animal health and production is facing challenges due to a variety of factors, e.g., because of their high costs (Mondal *et al*., 2013), general toxicity (Patel *et al*., 2013), drug residual problems in milk and meat (Elmanama and Albayoumi, 2016; Tochi *et al*., 2016) and development of drug resistance in ticks (Abbas *et al*., 2014; Coles and Dryden, 2014; Heath and Levot, 2015; Kumar and Partap, 2015; Muyobela *et al*., 2015; Vudriko *et al*., 2016) and GIN (Playford *et al*., 2014; Alonso-Diaz *et al*., 2008; Borges *et al*., 2015; Geurden *et al*., 2015; Muniz-Lagunes *et al*., 2015; Ramos *et al*., 2016). In addition, quality of antiparasitic drugs, particularly in developing countries, has led to attention of the stakeholders to find alternatives, may be as a part of drug resistance

To cite this paper: Zaman, M.A., Z. Iqbal, Z.U.D. Sindhu, R.Z. Abbas and M.F. Qamar, 2017. An Overview of Plants with Acaricidal and Anthelmintic Properties. *Int. J. Agric. Biol.,* 19: 957–968

management programs (Zaman *et al*., 2012a,b; Sindhu *et al*., 2014; Ghosh *et al*., 2015a; Kumar *et al*., 2016). Prospects of using plants as alternates to synthetic antiparasitic drugs have been discussed in the following paragraphs.

Plants as Anti-parasitics

Plants and/or their products have been used for treatment of different diseases for centuries. There is an extended relationship among the coexistence of herbal remedies, parasites and humans (Matsabisa *et al*., 2013). It is as old as history of man itself. The plant kingdom is a vast storehouse of chemical substances manufactured and used by plants as defenses against insects, bacteria, fungi and viruses (Rattan, 2010; Mithöfer and Boland, 2012; Aslam *et al.,* 2016). Plants are known to produce a range of secondary metabolites such as terpenoids, alkaloids, polyacetylenes, flavanoids and unusual amino acids and sugars (Chen *et al*., 2011; Savithramma *et al*., 2011; Hussain *et al*., 2012), for their defense from attack by pests. Plants constitute major part of the traditional veterinary practices termed as "ethnoveterinary medicine (EVM)" (Upadhyay *et al*., 2011; Asadbeigi *et al*., 2014). These plants may also posses' biological activity against significant parasites of veterinary standpoint, which could effectively be used to control ecto- and endo-parasites post-scientific validation. The efficacy of plant extracts/products against endo- and ecto-parasites of animals have been reported with variable success (e.g., Chen *et al*., 2011; Maphosa and Masika, 2012; Martinez-Ortiz-de-Montellano *et al*., 2013; Mbaya and Ogwiji, 2014; Silva *et al*., 2014; Abbas *et al.*, 2014, 2015, 2017; Kumarasinghe *et al*., 2016). Most frequently used plants are sown either by the farmers or found self-grown, in the fields. These can also be obtained from the herbal/grocery stores easily. Farmers can use the wild herbs by uprooting from fields. In Pakistan, farmers believe that control of a parasite of a particular region is provided by nature in the form the indigenous plants of the area (Personal Communication). In tropical countries, common-and-economic availability of plants render them to be most viable options as alternates of synthetic antiparasitics drugs (Chander *et al*., 2013; Neergheen-Bhujun, 2013; Tamboli *et al*., 2015). Literature on the use of plants as acaricides and anthelmintics has been selectively reviewed as under:

Plants Used as Acaricides

For the last ten years (2005–2015), 58% increase in citation of plants against ticks per year has been noticed (Bhardwaj *et al*., 2012; Benelli *et al*., 2016). However, in Pakistan, only a handful number of plants have been used against *R. microplus* (Zaman *et al*., 2012a; Sindhu *et al*., 2012; Nawaz *et al*., 2015) in contrast to more extensive investigations elsewhere (Chen *et al*., 2011; dos Santos *et al*., 2013; Nyahangare *et al*., 2015; Fouche *et al*., 2016a,b). Some plants reported for their anti-tick activity (acaricides) have been selectively reviewed and listed in Table 1.

Tests Used for Evaluation of Anti-tick Activity

***In vitro*:** Plants have been mostly evaluated through *in vitro* bioassays for preliminary screening. Three tests have been often used, i.e., Larval immersion test, larval packet test adult immersion test and syringe test.

Larval immersion test (LIT): This test takes around six weeks for results and is not recommended by FAO (FAO, 2004). Briefly, fully blood engorged female ticks are immersed in various concentrations of the candidate drugs for 2–4 min. All the ticks weighed together pre-immersion (WPI). The efficacy of the drug is measured on the basis of mortality (up to 14 days post-immersion), weight of the eggs laid by the ticks, reproductive index (RI) calculated by egg weight divided by WPI and oviposition inhibition (OI) (*RI control-RI treated/RI Control)*$\times$*100*). A major advantage of LIT is that it does not need any specific solvent rendering it more suitable for plants extracts.

Larval packet test (LPT): This is a time-efficient test and fully supported by FAO and have been adapted by many workers (Chagas *et al*., 2016; Vudriko *et al*., 2016). Briefly, larvae were inserted into drug impregnated filter paper for 24 hrs at certain temperature (27–29°C) and relative humidity (80–85%). Mortality and/or inhibition of larval motility are the criteria to measure the efficacy of the drugs. Trichloroethylene is used as solvent in LPT. Plant extracts are insoluble in this solvent thus only a limited number of scientists used this test for evaluation of efficacy. However, some workers modified LPT and have used acetone, ethanol and methanol in place of trichloroethylene (de Monteiro *et al.*, 2012; Singh *et al*., 2015). Only condition of the solvent is that it should not cause mortality of tick's larvae more than 5% in control group.

Adult immersion test: This test takes around four weeks and is recommended by FAO (FAO, 2004). Test needs to be conducted on only healthy ticks, and weight of the group of ticks and egg mass should be proportionate etc.); thus, only a few workers used this test (Parveen *et al*., 2014; Ghosh *et al*., 2015b). In this test, ticks are exposed to test product/drug for 30 sec and efficiency is measured by effect on egg laying capacity of the female ticks.

Syringe test: This is the most recently introduced test and basically is a modification of LIT. Main difference is use of 14 days old larvae, which are to be exposed to candidate drugs for 30 sec. Special syringes, with cutting nozzle end and withdrawn plunger (2 mL), are prepared. After placing eggs in the cutting end of the syringe, it closes tightly with organza fabric until eggs hatch out in around 14 days. The larvae are immersed for 30 sec and the syringe is placed in fume hood for drying (1 h). The main criterion of efficacy evaluation is larval mortality and inhibition of their motility/walk (Sindhu *et al*., 2012).

Table 1: Plants used as acaricides

Plant	Part used	Plant family	Reference (s)
Acanthus ebracteatus	Leaf	Acanthaceae	Chungsamarnyart *et al*., 1988
Acorus calamus	Rhizome	Acoraceae	Pathak *et al*., 2004
Aegle marmelos	Leaf	Rutaceae	Kamaraj *et al.,* 2011
Ageratum houstonianum	Leaf	Asteraceae	Pamo *et al*., 2005; Parveen *et al*., 2014
Ageratum conyzoides	Whole plant	Asteraceae	Kumar *et al.,* 2016
Allium sativum	Bulb	Amaryllidaceae	Shyma *et al.,* 2014
Annona squamosal	Seed	Annonaceae	Ilham *et al.,* 2014
Artemisia absinthium	Oil	Asteraceae	Thakur *et al*., 2007; Godara *et al.*, 2014
Azadirachta indica	Oil	Meliaceae	Thakur *et al*., 2007
	Bark		Pathak *et al*., 2004; Maharaj *et al*.,2005
	Leaf		Handule *et al*., 2002; Pathak *et al*., 2004, Nawaz et al., 2015
	Seed		Chagas *et al.,* 2016
Citrus spp.	Peel oil	Rutaceae	Ghosh *et al*., 2015b
Cymbopogon winterianus	Essential oil	Poaceae	de Mello *et al.,* 2014
Dahlstedtia pentaphylla	Root	Fabaceae	Pereira and Famadas, 2006
Datura stramonium	Leaves	Solanaceae	Ghosh *et al*.., 2015a
Drimys brasiliensis	Essential oil of stem/leaf	Winteraceae	Ribeiro *et al*., 2007, Ribeiro *et al*., 2008
Gynandropsis gynandra	Essential oil	Cleomaceae	Malonza, 1992; Lwande *et al*., 1999
Hypericum polyanthemum	Aerial part	Hypericaceae	Ribeiro *et al*.,2007
Lavandula officinalis	Essential oil	Lamiaceae	Abdel-Shafy and Soliman, 2004
Lippia gracilis	Essential oil	Verbenaceae	Cruz *et al.*, 2013
Luffa acutangula	Not Reported	Cucurbitaceae	Chungsamarnyart *et al.,* 1988
Margaritaria discoidea	Not Reported	Phyllanthaceae	Kaaya *et al.,* 1995
Marjorana hortensis	Not Reported	Lamiaceae	Abdel-Shafy and Soliman, 2004
Matricaria chamomile	Flower	Asteraceae	Pirali-Kheirabadi and Razzaghi-Abyaneh, 2007
Melia azedarach	Leaf	Meliaceae	Matias *et al.,* 2003
	Fruit		Sousa *et al.,* 2011
Melinis minutiflora	Whole plant	Poaceae	Muro *et al.* 2004, Fernandez-Ruvalcaba *et al.* 2004
Mentha piperita	Whole plant	Lamiaceae	Abdel-Shafy and Soliman, 2004; Chagas *et al.* 2016
Neoglaziovia variegata	Leaves and aerial part	Bromeliaceae	Dantas *et al.,* 2015
Nicotiana tabacum	Leaf	Solanaceae	Choudhary *et al.*, 2004; Maroyi, 2012, Zaman *et al*., 2012a, Farooq *et al.*, 2008
Ocimum basilicum	Leaves	Lamiaceae	Abdel-Shafy and Soliman, 2004; Martinez-Velazquez *et al.,* 2011, Veeramani *et al*., 2014
Ocimum suave	Leaf	Lamiaceae	Mwangi *et al.,* 1995, Magona *et al.,* 2011
Pimentadioica dioica	Bark and leaf; Seed	Myrtaceae	Brown *et al*., 1998; Martinez-Velazquez *et al*., 2011
Pongamia pinnata	Essential Oil, Seed	Fabaceae	Thakur *et al*., 2007; Handule *et al.,* 2002
Cleome hirta	Essential oil	Capparaceae	Ndungu *et al*., 1999
Sapindus saponaria	Stem	Sapindaceae	Fernandes *et al.* 2005
Semecarpus anacardium	Leaves	Anacardiaceae	Ghosh *et al.* 2015a
Stemona collinsiae	Rhizomes; Root	Stemonaceae	Chungsamarnyart *et al.,* 1988; Kongkiatpaiboon *et al.,* 2014
Stylosanthes hamata	Aerial parts	Fabaceae	Fernandez-Ruvalcaba *et al.,* 1999, Muro *et al.,* 2003
Stylosanthes humilis	Aerial parts	Fabaceae	Fernandez-Ruvalcaba *et al.,* 1999, Muro *et al.,* 2003
Syzygiumaromaticum	Essential oil	Myrtaceae	de Mello *et al.,* 2014
Tamarindus indicus	Seeds; Fruits	Fabaceae	Guneidy *et al.,* 2014
Vitex agnus-castus	Seed	Lamiaceae	Mehlhorn *et al.,* 2005

Ticks used in experimental and/or natural infestations in above cited studies in decreasing order of frequency were *Rhipicepahlus microplus, R. annulatus, R. appendiculatus, R. sanguineus, R. haemaphysaloides* and *R. pulchellus*

***In vivo* ear bag method:** A muslin cloth bag is fabricated (13 × 17 cm) to facilitate attachment of seed ticks (freshly hatched larvae) on the animals. After successful attachment of the seed ticks, the candidate drugs are applied topically. The evaluation criterion is number of ticks droping off the animal (Ghosh *et al*., 2011, 2013, 2015a,b; Zaman *et al*., 2012a).

Plants Used as Anthelmintics

Worldwide, a number of medicinal plants have been used to treat gastro-intestinal helminthiasis (Orr, 2015; Habibi *et al*., 2016; Nosal *et al*., 2016; Liaqat *et al.,* 2016). An account of the plants used as anthelmintics is given in Table 2.

Tests Used for Evaluation of Anthelmintic Activity

The tests and test worms used by different workers to evaluate the efficacy of plants have been presented in Table 2.

Egg hatch test: Fresh eggs (unhatched eggs) are incubated for 72 h with various concentrations of candidate drugs. Inhibition of hatching is main criterion for efficacy of the candidate drugs. Inhibition of hatching is main criterion for efficacy of the candidate drugs (Coles *et al.*, 2006). Eggs for this test are either isolated from faeces of donor animals or by triturating the female *H. contortus* in Phosphate Buffer Saline after collection from abomasum of slaughterd animals. Eggs obtained from female *H. contortus* could be of diferent stages of embryonation so copro-purified eggs generate more reliable results (Taylor *et al*., 2002; Várady *et al*., 2007). Tap water has been used for preparation of serial dilutions of the candidate drugs by many researchers, which have been found inappropriate because ions naturally present in the water effect on egg hatching.

Table 2: Plants used as anthelmintics

Plant	Part used	Helminth (s)	Family	Reference (s)
Acacia albida	Seed	Mixed infection of GIN	Fabaceae	Nwude & Ibrahim, 1980
Acacia gaumeri	Leaves	*Haemonchus controtus*	Fabaceae	Alonso-Diaz *et al.*, 2011
Acacia pennatula	Leaves	*Haemonchus controtus*	Fabaceae	Alonso-Diaz *et al.*, 2008
Acacia nilotica	Fruit	Mixed infection of GIN	Fabaceae	Bachaya *et al.*, 2009
Adhatoda vasica	Root and leaf	Mixed infection of GIN	Acanthaceae	Al-Shaibani *et al.*, 2009b; Somnath *et al.*, 2015
Agrimonia eupatoria	Not Reported	Mixed infection of GIN	Rosaceae	Farnsworth *et al.*, 1985
Albizia anthelmintica	Bark	Mixed infection of GIN	Mimosaeae	Minja, 1989
	Root	*Haemonchus contortus*		Githiori *et al.* 2003; Gathuma *et al.* 2004; Grade *et al.* 2008
Allium sativum	Bulb	*Haemonchus contortus*; Mixed infection of GIN	Amaryllidaceae	Iqbal *et al.*, 2001, Ahmed *et al.*, 2014
Aloe ferox	Leaves	*Haemonchus contortus*	Asphodelaceae	Maphosa *et al.*, 2010
Amomum aromaticum	Seeds	*Haemonchus contortus*	Zingiberaceae	Kaushik *et al.*, 1981
Anacardium occidentale	Essential oil	*Haemonchus contortus*	Anacardiaceae	Ademola & Eloff, 2011
Ananas comosus	Not reported	*Haemonchus contortus*	Bromeliaceae	Ahmed *et al.*, 2014
Areca catechu	Nut	*Haemonchus contortus*	Arecaceae	Barbieri *et al.*, 2014
Artemisia brevifolia	Whole plant	*Haemonchus contortus*	Compositae	Iqbal *et al.*, 2004; Irum *et al.*, 2015
Artemisia herbaalba	Shoot	*Haemonchus contortus*	Asteraceae	Idris *et al.*, 1982; Seddiek *et al.*, 2011
Azadirachta indica	Leaf	Mixed infection of GIN; *Haemonchus contortus*	Meliaceae	Radhakrishnan *et al.*, 2007; Jamra *et al.*, 2015
	Seed	*Haemonchus contortus*		Hördegen *et al.*, 2006, Costa *et al.*, 2008
		Mixed infection of GIN		Iqbal *et al.*, 2010
	Cake and Leaf	Mixed infection of GIN		Gowda, 1997; Mostofa *et al.*, 1996
Boswellia dalzielii	Bark	Mixed infection of GIN	Burseraceae	Nwude and Ibrahim,1980
Butea Spp.	Various parts	*Haemonchus contortus;* Mixed infection of GIN	Fabaceae	Singh *et al.*, 2015; Lateef *et al.*, 2006b; Iqbal *et al.*, 2006
Caesalpinia crista	Seed	Mixed infection of GIN; *Haemonchus contortus*	Fabaceae	Jabbar *et al.*, 2007; Bhardwaj *et al.*, 2015
	Fruit	Mixed infection of GIN		
Calliandra calothyrsus	Legume	*Haemonchus contortus*	Fabaceae	Cresswell, 2007; Florence & Mbida, 2011,
Calotropis procera	Flower	Mixed infection of GIN	Apocynaceae	Iqbal *et al.*, 2005
	Latex	*Haemonchus contortus*		Murti *et al.*, 2015; Cavalcante *et al.*, 2016
Carum copticum	Seed	Mixed infection of GIN	Apiaceae	Lateef *et al.*, 2006a; Boskabady *et al.*, 2014
Carissa edulis	Root	Mixed infection of GIN	Apocynaceae	Mishra *et al.*, 2012
Cassia spectabilis	Root	*Haemonchus contortus*	Fabaceae	Morais-Costa *et al.*, 2015
Chenopodium album	Whole plant	Mixed infection of GIN	Amaranthaceae	Jabbar *et al.*, 2007 ; Nayak *et al.*, 2010
Chenopodium ambrosioides	Leaf	Haemonchus contortus; Mixed infection of GIN	Amaranthaceae	Eguale & Giday, 2009; Salifou *et al.*, 2013
	Essential oil	*Haemonchus contortus*; Mixed infection of GIN		Ketzis *et al.*, 2002; Macdonald *et al.*, 2004
Chrysophyllum cainito	Stem	*Haemonchus contortus*	Sapotaceae	Fernandez *et al.*, 2013
Coriandrum sativum	Seeds	*Haemonchus contortus*	Apiaceae	Eguale *et al.*, 2007
Cucurbita Mexicana	Seeds	*Haemonchus contortus*	Cucurbitaceae	Iqbal *et al.*, 2001
Cymbopogon nardus	Whole plant	Haemonchus contortus	Poaceae	Jeyathilakan *et al.*, 2010
Dalbergia latifolia	Bark and Stem	*Haemonchus contortus*	Fabaceae	Daryatmo *et al.*, 2010
Elephantorrhiza elephantina	Roots	*Haemonchus contortus*	Fabaceae	Maphosa *et al.*, 2010
Embelia ribes	Seed	*Haemonchus contortus*	Myrsinaceae	Swarnkar *et al.*, 2009
Erythrina senegalensis	Bark	*Haemonchus contortus*	Fabaceae	Williams *et al.*, 2016
Eucalyptus globulus	Leaves	*Haemonchus contortus*	Myrtaceae	Kanojiya *et. al.*, 2016
Fagara heitzii	Leaves	Mix infection of GIN	Rutaceae	Hounzangbe *et al.*, 2005
Ferula foetidissima	Not Reported	*Haemonchus contortus*	Apiaceae	Pustovoi, 1968
Ficus religiosa	Bark	*Haemonchus contortus*	Urticaceae	Iqbal *et al.*, 2001
Fumaria parviflora	Whole plant	Mixed infection of GIN	Fumariaceae	Al-Shaibani *et al.*, 2009a
Hagenia abyssainica	Fruit	Mixed infection of GIN	Rosaceae	ITDG and IIRR, 1996
Heracleum sosnowskyi	Not Reported	Mixed infection of GIN	Apiaceae	Gadzhiev and Eminove, 1986a, b
Lagenaria siceraria	Seed	Haemonchus contortus; *Pheretima posthuma* (Earthworm)	Cucurbitaceae	Khan *et al.*, 2010a
Lawsonia inermis	Flower and seed	*Eicinia fetida* (Red californian earthworm)	Lythraceae	Wadekar *et al.*, 2016
Leonotis leonurus	Leaves	Mix infection of GIN	Lamiaceae	Maphosa *et al.*, 2010
Leucaena leucocephala	Leaves	*Haemonchus contortus*	Fabaceae	Alonso-Diaz *et al.*, 2008
Lippia sidoides	Essential oil	Mix infection of GIN	Verbenaceae	Camurça-Vasconcelos *et al.*, 2008
Lysiloma latisiliquum	Leaves	*Haemonchus contortus*; Mix infection of GIN	Fabaceae	Alonso-Diaz *et al.*, 2008; Brunet *et al.*, 2008
Mallotus philippinensis	Fruit, powder	Mix infection of GIN	Euphorbiaceae	Gangwar *et al.*, 2013
Melia azedarach	Fruit	Mixed infection of GIN	Meliaceae	Cala *et al.*, 2012
Momordica charantia	Fruits	*Haemonchus contortus*	Cucurbitaceae	Rashid *et al.*, 2016
Moringa oleífera	Root	Mixed infection of GIN	Moringaceae	Salles *et al.*, 2014
Musa paradisiaca	Leaves	Mix infection of GIN	Musaceae	Hussain *et al.*, 2010, 2011, Marie-Magdeleine *et al.*, 2014
Myracrodr uonurundeuva	Leaves	*Haemonchus contortus*	Anarcadiaceae	de Oliveira *et al.*, 2011
Myrsine Africana	Leaves	*Haemonchus contortus*	Myrsinaceae	Getachew *et al.*, 2012
Nicotiana tabacum	Leaves	*Haemonchus contortus*	Solanaceae	Iqbal *et al.*, 2006, Worku *et al.*, 2009, Epperson, 2013, Hamad *et al.*, 2013
Nigella sativa	Seed	*Haemonchus contortus*	Ranunculaceae	Burke *et al.*, 2009, Shalaby *et al.*, 2012
Piscidia piscipula	Leaves	*Haemonchus contortus*	Fabaceae	Alonso-Diaz *et al.*, 2008
Rapanea melanophloeos	Fruits	*Haemonchus contortus*	Myrsinaceae	Githiori *et al.*, 2002
Scutia myrtina	Roots	*Haemonchus contortus*	Rhamnaceae	Ayers *et al.*, 2007
Semecarpus anacardium	Nut	Mixed infection of GIN; *Haemonchus contortus*	Anacardiaceae	Pal *et al.*, 2008; Tandon *et al.*, 2011
Spigelia anthelmia	Aerial parts	*Haemonchus contortus*	Loganiaceae	Ademola *et al.*, 2007
Thymus capitatus	Aerial parts	Mixed infection of GIN	Lamiaceae	Elandalousi *et al.*, 2013
Trachyspermum ammi	Seed	*Haemonchus contortus*	Apiaceae	Jabbar *et al.*, 2006, Lateef *et al.*, 2006c
Trianthema portulacastrum	Whole plant	Mix infection of GIN; *Haemonchus contortus*	Aizoaceae	Hussain *et al.*, 2011, de Mello *et al.*, 2013
Vernonia anthelmintica	Seed	*Haemonchus contortus*	Asteraceae	
Zingiber officinale	Rhizome	Mixed infection of GIN	Zingiberaceae	Peachey *et al.*, 2015
Ziziphus nummularia	Bark	Mixed infection of GIN	Rhamnaceae	Bachaya *et al.*, 2009

GIN = gastrointestinal nematodes

Only those plants were selected which showed significant reduction (35%, 5>) in fecal egg counts as compared to control

Thus, protocol of this test has been revolutionized by using distilled deionized water as solvent of drugs in lieu of tap water (von Samson-Himmelstjerna *et al*., 2009).

Larval migration inhibition assay: Young larvae, less than two weeks, are kept with various concentrations of candidate drugs in dark. Post 24 h incubation, contents are sieved and larvae are allowed to migrate for 24 h. The sieve containing un-migrated larvae is washed carefully in separate wells. Success of the test is measured by inability of larvae to migrate through sieve due to paralysis (Alonso-Díaz *et al*., 2011; Kamaraj and Rahuman, 2011).

Larval development assay: This test measure shifts of first larval stages of Trichostronglids to infective stage (Third larval stage) and takes 6–7 days to be completed (Demeler *et al*., 2010). Briefly, eggs are collected from faeces of donor animals. At least five serial dilutions (10 µL) of candidate extract dissolved in DMSO/Distilled are dispensed in different wells of 96 well micro titration plate having 190 µL Agar (2%), nutritive media (Earle's balanced salt solution, Bacteria and yeast extract) and amphotericin B. About 100 eggs (10 µL) are dispensed in these wells containing plant extract and incubated at 25°C for 6 days (to obtain L3). At the end of incubation period Lugol's iodine solution is added in each well and number of eggs (un-hatched), L1, L2 and L3 are counted.

Adult motility assay: The basic theology of this test is similar as described in larval migration inhibition test. Adult worms collected from freshly slaughtered animals are subjected to various drug concentrations for 6 h. Observance of motility for 30 min in PBS post-treatment is main criteria. Breifly, adult worms collected from freshly slaughtered animals are subjected to various drug concentrations for 6 h. Dead and alive worms are counted in each test concentration at hourly basis. To confirm death of the worm non-motile worms are exposed to luke warm water for ~ 1 min. This test is used to obtain time dependent as well as dose dependent data on mortality of worms (Ferreira *et al*., 2016; Raza *et al.,* 2016; Uppala *et al*., 2016).

***In vivo*:** Fecal egg count reduction test and post-mortem examination are the two tests to perform *in vivo* anthelmintic assessment trials. Former test is adopted most due to ease of conduction and being inexpensive (Lone *et al*., 2012, 2013; Mondal *et al*., 2015; Grzybek *et al*., 2016).

Fecal egg count reduction test: Efficacy is measured through reduction of number of eggs in fecal samples post-treatment with candidate drug (Khan *et al.,* 2015; Meenakshisundaram *et al.,* 2016). Fecundity of *H. contortus* is high. So, it yields best reliable results in case of *H. contortus* due to strong positive correlation between magnitudes of infection with number of eggs in feces. Animals of about same age, either sex and approximately equal weight are randomly divided in treatment groups. Animals are administered with different levels of plant extracts at day 0 and faecal egg counts are performed at day 0, 7 and 14 post-treatment. Efficacy is measured through reduction of number of eggs in fecal samples post-treatment with candidate drug. Fecundity of *H. contortus* is high. So, it yields best reliable results in case of *H. contortus* due to strong positive correlation between magnitudes of infection with number of eggs in feces (Rowe *et al*., 2008).

Table 3: Plant families (%) studied as acaricidal and anthelmintics

Family	Acaridcidal	Anthelmintic
Acanthaceae	0.41	1.41
Aizoaceae	0	1.41
Amaryllidaceae	0.41	2.87
Anacardiaceae	0.41	4.23
Apiaceae	0	7.04
Apocynaceae	0	2.87
Arecaceae	0	1.41
Asphodelaceae	0	1.41
Asteraceae	1.29	2.84
Bromeliaceae	0.43	0.71
Burseraceae	0	0.71
Compositae	0	0.71
Cucurbitaceae	0.43	2.84
Ebenaceae	0	0.71
Euphorbiaceae	0	0.71
Fabaceae	2.15	16
Fumariaceae	0	0.71
Lamiaceae	2.58	2.28
Loganiaceae	0	0.71
Lythraceae	0	0.71
Meliaceae	0.86	2.28
Mimosaeae	0	0.71
Moringaceae	0	0.71
Musaceae	0	0.71
Myrsinaceae	0	2.13
Myrtaceae	0.86	1.42
Poaceae	0.86	0.71
Ranunculaceae	0	0.71
Rhamnaceae	0	1.42
Rosaceae	0	1.42
Sapotaceae	0	0.71
Solanaceae	0.86	0.71
Verbenaceae	0.43	0.71
Woodsiaceae	0	0.71
Zingiberaceae	0	1.42

Conclusion

Empirical and scientific evidence suggest several plants are moderately effective against ticks and helminthes in animals. Though there are several papers published and databases developed on the use of plants in animal health, yet lot has to be done to document the rich indigenous knowledge existing in different cultures around the globe. There is strong need to document the plants with their botanical and local names, indications of the usage both in technical and local languages, and standardization of plant based products as to their formulation and dosage. There is also need to develop more sensitive, convenient and reliable screening assays for scientific validation of the plants.

References

Abbas, R.Z., M.A. Zaman, D.D. Colwell, J. Gilleard and Z. Iqbal, 2014. Acaricide resistance in cattle ticks and approaches to its management: the state of play. *Vet. Parasitol.*, 203: 6–20

Abbas, R.Z., D.D. Colwell, Z. Iqbal and A. Khan, 2014. Acaricidal drug resistance in poultry red mite (*Dermanyssus gallinae*) and approaches to its management. *Worlds Poult. Sci. J.*, 70: 113–124

Abbas, A., Z. Iqbal, R.Z. Abbas, M.K. Khan, J.A. Khan, K. Hussain, M.S. Mahmood and H.M. Rizwan, 2017.Immunomodulatory effects of *Camellia sinensis* against coccidiosis in chickens. *J. Anim. Plant Sci*., 27(2): *In Press*

Abbas, A., Z. Iqbal, R.Z. Abbas, M.K. Khan and J.A. Khan, 2015. *In-vitro* anticoccidial potential of *Saccharum officinarum* extract against *Eimeria* oocysts. *Bol. Latinoamericano Y del Caribe de Plantas Med. y Aromat.*, 14: 456–461

Abdel-Shafy, S. and M.M.M. Soliman, 2004. Toxicity of some essential oils on eggs, larvae and females of *Boophilus annulatus* (Acari: Ixodida: Amblyommidae) infesting cattle in Egypt. *Acarol*., 44: 23–30

Ademola, I.O. and J.N. Eloff, 2011. Anthelmintic efficacy of cashew (Anarcadium occidentale L.) on in vitro susceptibility of the ova and larvae of *Haemonchus contortus*. *Afr. J. Biotechnol.*, 10: 9700–9705

Ademola, I.O., B.O. Fagbemi and S.O. Idowu, 2007. Anthelmintic activity of Spigelia anthelmia extract against gastrointestinal nematodes of sheep. *Parasitol. Res.*, 101: 63–69

Ahmed, M., M.D. Laing and I.V. Nsahlai, 2014. *In vitro* anthelmintic activity of crude extracts of selected medicinal plants against *Haemonchus contortus* from sheep. *J. Helminthol.*, 87: 174–179

Al-Shaibani, I.R.M., M.S. Phulan and M. Shiekh, 2009a. Anthelmintic activity of *Fumaria parviflora* (Fumariaceae) against gastrointestinal nematodes of sheep. *Int. J. Agric. Biol*., 11: 431–436

Al-Shaibani, I.R.M., M.S. Phulan, A. Arijo, T.A. Qureshi, M. Shiekh, F. Shahina, A.R. Kazmi and K. Firoza, 2009b. Anthelmintic activity of *Adhatoda vasica* against gastrointestinal nematodes of sheep: Pakistan Society of Nematologists, Karachi. *Pak. J. Nematol*., 27: 255–26

Alonso-Diaz, M.A., J.F. Torres-Acosta, C.A. Sandoval-Castro and H. Hoste, 2011. Comparing the sensitivity of two *in vitro* assays to evaluate the anthelmintic activity of tropical tannin rich plant extracts against *Haemonchus contortus*. *Vet. Parasitol.*, 181: 360–364

Alonso-Diaz, M.A., J.F. Torres-Acosta, C.A. Sandoval-Castro, A.J. Aguilar-Caballero and A.H. Hoste, 2008. *In vitro* larval migration and kinetics of exsheathment of *Haemonchus contortus* larvae exposed to four tropical tanniniferous plant extracts. *Vet. Parasitol*., 153: 313–319

Anonymous, 2014-2015. *Economic Survey of Pakistan*, pp: 216–226. Ministry of Finance, Govt. of Pakistan. Economic Advisor's Wing, Islamabad–Pakistan

Asadbeigi, M., T. Mohammadi, M. Rafieian-Kopaei, K. Saki, M. Bahmani and M. Delfan, 2014. Traditional effects of medicinal plants in the treatment of respiratory diseases and disorders: An ethnobotanical study in the Urmia. *Asian Pac. J. Trop. Med*., 7: S364–S368

Ashfaq, M., A. Razzaq, S. Haq and G. Muhammad, 2015. Economic analysis of dairy animal diseases in Punjab: A case study of Faisalabad district. *J. Anim. Plant Sci*., 25: 1482–1495

Aslam, A., M.I. Shahzad, S. Parveen, H. Ashraf, N. Naz, S.S. Zehra, Z. Kamran, A. Qayyum and M. Mukhtar, 2016. Evaluation of antiviral potential of different Cholistani plants against infectious bursal disease and infectious bronchitis virus. *Pak. Vet. J.*, 36: 302–306

Asmaa, N.M., M.A. ElBably and K.A. Shokier, 2014. Studies on prevalence, risk indicators and control options for tick infestation in ruminants. Beni-Suef University *J. Basic Appl. Sci*., 3: 68–73

Ayers, S., D.L. Zink, K. Mohn, J.S. Powell, C.M. Brown, T. Murphy, R. Brand, S. Pretorius, D. Stevenson and S.B.T. Singh, 2007. Scutiaquinones A and B, perylenequinones from the roots of *Scutia myrtina* with anthelmintic activity. *J. Natural prod.*, 70: 425–427

Bachaya, H.A., Z. Iqbal, M.N. Khan, Z.U. Sindhu and A. Jabbar, 2009. Anthelmintic activity of *Ziziphus nummularia* (bark) and *Acacia nilotica* (fruit) against Trichostrongylid nematodes of sheep. *J. Ethnopharmacol.*, 123: 325–329

Bansal, D.K., V. Agrawal and M. Haque, 2015. A slaughter house study on prevalence of gastrointestinal helminths among small ruminants at Mhow, Indore. *J. Parasitic Dis.*, 39: 773–776

Barbieri, A.M.E., F.B. Ceneviva, C.E. Breda, M.E. Luís and K.L. Morita, 2014. Effectiveness of Areca catechu linn against *Haemonchus contortus in vitro* egg hatch assay. *Bol. Ind. Anim.*, 71(Supl)

Benelli, G., R. Pavela, A. Canale and H. Mehlhorn, 2016. Tick repellents and acaricides of botanical origin: a green roadmap to control tick-borne diseases? *Parasitol. Res.*, 115: 2545–2560

Bhardwaj, A., K.C. Stafford and R.W. Behle, 2012. Efficacy and environmental persistence of nootkatone for the control of the blacklegged tick (Acari: Ixodidae) in residential landscapes. *J. Med. Entomol*., 49: 1035–1044

Bhardwaj, L.K., K. Kaushal, Chandrul and U.S. Sharma, 2015. Evaluation of anthelmintic activity of *Caesalpinia crista* Linn. seed extracts. *World J. Pharm. Pharmaceut. Sci*., 5: 976–982

Borges Fde, A., D.G. Borges, R.P. Heckler, J.P. Neves, F.G. Lopes and M.K. Onizuka, 2015. Multispecies resistance of cattle gastrointestinal nematodes to long-acting avermectin formulations in Mato Grosso do Sul. *Vet. Parasitol*., 212: 299–302

Borji, H., M. Azizzadeh, M. Ebrahimi and M. Asadpour, 2012. Study on small ruminant lungworms and associated risk factors in northeastern Iran. *Asian Pacific J. Trop. Med.*, 5: 853–856

Boskabady, M.H., S. Alitaneh and A. Alavinezhad, 2014. Carum copticum L.: A herbal medicine with various pharmacological effects. *Res. Int*., 569087

Brown, H.A., D.A. Minott, C.W. Ingram and L.A.D. Williams, 1998. Biological activities of the extracts and constituents of pimento, Pimenta dioica L. against the southern cattle tick, *Boophilus microplus. Insect Sci. Appl.*, 18: 9–16

Brunet, S., C.M. De Montellano, J.F. Torres-Acosta, C.A. Sandoval-Castro, A.J. Aguilar-Caballero, C. Capetillo-Leal and H. Hoste, 2008. Effect of the consumption of *Lysiloma latisiliquum* on the larval establishment of gastrointestinal nematodes in goats. *Vet. Parasitol*., 157: 81–88

Burke, J.M., A. Wells, P. Casey and R.M. Kaplan, 2009. Herbal dewormer fails to control gastrointestinal nematodes in goats. *Vet. Parasitol*., 160: 168–170

Cala, A.C., A.C.S. Chagas, M.C.S. Oliveira, A.P. Matos, L.M.F. Borges, L.A.D. Sousa, F.A. Souza, and G.P. Oliveira, 2012. In vitro anthelmintic effect of *Melia azedarach* L. and *Trichilia claussenii* C. against sheep gastrointestinal nematodes. *Exp. Parasitol*., 130: 98–102

Camurca-Vasconcelos, A.L., C.M. Bevilaqua, S.M. Morais, M.V. Maciel, C.T. Costa, I.T. Macedo, L.M. Oliveira, R.R. Braga, R.A. Silva, L.S. Vieira and A.M. Navarro, 2008. Anthelmintic activity of *Lippia sidoides* essential oil on sheep gastrointestinal nematodes. *Vet. Parasitol.*, 154: 167–170

Cavalcante, G.S., S.M. De Morais, W.P. Andre, W.L. Ribeiro, A.L. Rodrigues, F.C. De Lira, J.M. Viana and C.M. Bevilaqua, 2016. Chemical composition and *in vitro* activity of *Calotropis procera* (Ait.) latex on *Haemonchus contortus*. *Vet. Parasitol.*, 226: 22–25

Chagas, A.C., M.C. Oliveira, R. Giglioti, R.C. Santana, H.R. Bizzo, P.E. Gama and F.C. Chaves, 2016. Efficacy of 11 Brazilian essential oils on lethality of the cattle tick *Rhipicephalus* (Boophilus) *microplus*. *Ticks. Tick-borne. Dis*., 7: 427–432

Chand, K.K., K.M. Lee, N.A. Lavidis, M. Rodriguez-Valle, H. Ijaz, J. Koehbach, R.J. Clark, A. Lew-Tabor and P.G. Noakes, 2016. Tick holocyclotoxins trigger host paralysis by presynaptic inhibition. *Sci. Rep.*, 6: 29446

Chander, M., B. Subrahmanyeswari, R. Mukherjee and S. Kumar, 2013. Organic livestock production: an emerging opportunity with new challenges for producers in tropical countries. *Rev. Sci. Tech.*, 30: 969–983

Chen, Y.G., J.C. Wu, G.Y. Chen, C.R. Han and X.P. Song, 2011. Chemical constituents of plants from the genus *Trigonostemon*. *Chem. Biodiv*., 8: 1958–1967

Chen, Z., Q. Liu, J.Q. Liu, B.L. Xu, S. Lv, S. Xia and X.N. Zhou, 2014. Tick-borne pathogens and associated co-infections in ticks collected from domestic animals in central China. *Parasite Vectors*, 7: 237

Choudhary, R.K., C. Vasanthi, B.R. Latha and L. John, 2004. *In vitro* effect of *Nicotiana tabacum* aqueous extract on *Rhipicephalus haemaphysaloides* ticks. *Ind. J. Anim. Sci.*, 74: 730–731

Chungsamarnyart, N., S. Jiwajinda, W. Jansawan, U. Kaewsuwan and P. Buranasilpin, 1988. Effective plant crude-extracts on the tick (*Boophilus microplus*) larvicidal action. *Kasetsart J. Nat. Sci*., 22: 37–41

Coles, G.C., F. Jackson, W.E. Pomroy, R.K. Prichard, G. von Samson-Himmelstjerna, A. Silvestre, M.A. Taylor and J. Vercruysse, 2006. The detection of anthelmintic resistance in nematodes of veterinary importance. *Vet. Parasitol*. 136: 167–185

Coles, T.B. and M.W. Dryden, 2014. Insecticide/acaricide resistance in fleas and ticks infesting dogs and cats. *Para. Vect*., 7: 8

Costa, C.T.C., C.M.L. Bevilaqua, A.L.F. Camurça-Vasconcelos, M.V. Maciel, S.M. Morais, C.M.S. Castro, R.R. Braga and L.M.B. Oliveira, 2008. *In vitro* ovicidal and larvicidal activity of Azadirachta indica extracts on *Haemonchus contortus*. *Small Rumin. Res.*, 74: 284–287

Cresswell, K.J., 2007. *Anthelmintic Effects of Tropical Shrub Legumes in Ruminant Animals*. Doctoral dissertation, James Cook University, Australia

Cruz, E.M., L.M. Costa-Junior, J.A. Pinto, D.A. Santos, S.A. Araujo, M.F. Arrigoni-Blank, L. Bacci, P.B. Alves, S.C. Cavalcanti and A.F. Blank, 2013. Acaricidal activity of *Lippia gracilis* essential oil and its major constituents on the tick *Rhipicephalus* (Boophilus) *microplus*. *Vet. Parasitol*., 195: 198–202

Dalal, S., A. Prasad, A. Nasir and V.K. Saini, 2015. Cross antigenicity of immunodominant polypeptides of somatic antigen of *Oesophagostomum columbianum* with other helminths by western blotting. *Vet. World,* 8: 1279–1285

Dantas, A.C., D.M. Machado, A.C. Araujo, R.G. Oliveira-Junior, S.R. Lima-Saraiva, L.A. Ribeiro, J.R. Almeida and M.C. Horta, 2015. Acaricidal activity of extracts from the leaves and aerial parts of *Neoglaziovia variegata* (Bromeliaceae) on the cattle tick Rhipicephalus (Boophilus) microplus. *Res. Vet. Sci.*, 100: 165–168

Daryatmo, J., H. Hartadi, E.R. Orskov, K. Adiwimarta and W. Nurcahyo, 2010. *In vitro* screening of various forages for anthelmintic activity on *Haemonchus contortus* eggs. *Adv. Anim. Biosci*., 1: 113–113

De Mello Peixoto, E.C.T., F. Valadares, L.P. da Silva and R.M. Gonccedil, 2013. Phytotherapy in the control of helminthiasis in animal production. *Afr. J. Agric. Res.,* 8: 2421–2429

De Mello, V., M.C. Prata, M.R. Da Silva MR, E. Daemon, L.S. Da Silva, G. Guimaraes Fdel, A.E. De Mendonca, E. Folly, F.M. Vilela and L.H. Do Amaral, 2014. Acaricidal properties of the formulations based on essential oils from *Cymbopogon winterianus* and *Syzygium aromaticum* plants. *Parasitol. Res.,* 113: 4431–4437

de Monteiro, C.M., R. Maturano, E. Daemon, F.E.A., Catunda-Junior, F. Calmon, T. de Souza Senra, A. Faza and de Carvalho, M.G., 2012. Acaricidal activity of eugenol on *Rhipicephalus microplus* (Acari: Ixodidae) and *Dermacentor nitens* (Acari: Ixodidae) larvae. *Parasitol. Res.*, 111: 1295–1300

De Oliveira, L.M., C.M. Bevilaqua, I.T. Macedo, S.M. De Morais, L.K. Machado, C.C. Campello and M. De Aquino Mesquita, 2011. Effects of *Myracrodruon urundeuva* extracts on egg hatching and larval exsheathment of *Haemonchus contortus*. *Parasitol. Res.*, 109: 893–898

Demeler, J., U. Küttler, A. El-Abdellati, K. Stafford, A. Rydzik, M. Varady, F. Kenyon, G. Coles, J. Höglund, F. Jackson and J. Vercruysse, 2010. Standardization of the larval migration inhibition test for the detection of resistance to ivermectin in gastro intestinal nematodes of ruminants. *Vet. Parasitol*., 174: 58–64

Demessie, Y. and S. Derso, 2015. Tick borne hemoparasitic diseases of ruminants: A Review. *Adva. Biol. Res.*, 9: 210–224

dos Santos, L.B., J.K. Souza, B. Papassoni, D.G. Borges, G.A. Damasceno, J.M. Jr., de Souza, C.A. Carollo and A. Borges Fde, 2013. Efficacy of extracts from plants of the Brazilian pantanal against *Rhipicephalus* (Boophilus) *microplus*. *Braz. J. Vet. Parasitol*., 22: 532–538

Duvallet, G. and P. Boireau, 2015. Other vector-borne parasitic diseases: animal helminthiases, bovine besnoitiosis and malaria. *Rev. Sci. Technol.,* 34: 651–658

Eguale, T. and M. Giday, 2009. In vitro anthelmintic activity of three medicinal plants against *Haemonchus contortus*. *Int. J. Green Pharm. (IJGP)*, 3: 29–34

Eguale, T., G. Tilahun, A. Debella, A. Feleke and E. Makonnen, 2007. *In vitro* and *in vivo* anthelmintic activity of crude extracts of *Coriandrum sativum* against *Haemonchus contortus*. *J. Ethnopharmacol.,* 110: 428–433

Elandalousi, R.B., H. Akkari F. B'chir, M. Gharbi, M. Mhadhbi, S. Awadi and M.A. Darghouth, 2013. *Thymus capitatus* from Tunisian arid zone: chemical composition and in vitro anthelmintic effects on *Haemonchus contortus*. *Vet. Parasitol*., 197: 374–378

Elmanama, A.A. and M.A. Albayoumi, 2016. High prevalence of antibiotic residues among broiler chickens in Gaza strip. *Food and Public Health*, 6: 93–98

Epperson, B., 2013. Combination of *Nicotiana tabacum* and *Azadirachta indica*: A novel substitute to control Levamisole and Ivermectin-resistant *Haemonchus contortus* in Ovine

FAO, 2004. Resistance management and integrated parasite control in ruminants: guidelines. Module 1. *Ticks: Acaricide Resistance: Diagnosis, Management and Prevention*. pp. 25–77. Rome, Italy

Farnsworth, N.R., O. Akerele, A.S. Bingel, D.D. Soejarto and Z. Guo, 1985. Medicinal plants in therapy. *Bull. WHO,* 6: 965–981

Farooq, Z., Z. Iqbal, S. Mushtaq, G. Muhammad, M.Z. Iqbal and M. Arshad, 2008. Ethnoveterinary practices for the treatment of parasitic diseases in livestock in Cholistan desert (Pakistan). *J. Ethnopharmacol*., 118: 213–219

Fernandes, F.D.F., E.D.P.S. Freitas, A.C.D. Costa and I.G.D. Silva, 2005. Larvicidal potential of *Sapindus saponaria* to control the cattle tick *Boophilus microplus. Pesq. Agropec. Bras.,* 40: 1243–1245

Fernandez, Jr., T.J., H.P. Portugaliza, F.B. Braga, E.A. Vasquez, A.D. Acabal, B.P. Divina and W.B. Pedere, 2013. Effective dose (ED) and quality control studies of the crude ethanolic extract (CEE) mixture of makabuhay, Caimito and Makahiya (MCM) as dewormer for goats against *Haemonchus contortus*. *Asian J. Exp.. Biol*. *Sci*., 4: 28–35

Fernandez-Ruvalcaba, M., C. Cruz-Vazquez, J. Solano-Vergara and Z. Garcia-Vazquez, 1999. Anti-tick effects of *Stylosanthes humilis* and *Stylosanthes hamata* on plots experimentally infested with *Boophilus microplus* larvae in Morelos, Mexico. *Exp. Appl. Acarol*., 23: 171–175

Fernandez-Ruvalcaba, M., F. Preciado-De-La Torre, C. Cruz-Vazquez and Z. Garcia-Vazquez, 2004. Anti-tick effects of *Melinis minutiflora* and *Andropogon gayanus* grasses on plots experimentally infested with *Boophilus microplus* larvae. *Exp. App. Acarol.*, 32: 293–299

Ferreira, L.E., B.I. Benincasa, A.L. Fachin, S.C. França, S.S. Contini, A.C. Chagas and R.O. Beleboni, 2016. *Thymus vulgaris* L. essential oil and its main component thymol: Anthelmintic effects against *Haemonchus contortus* from sheep. *Vet. Parasitol*., 228: 70–76

Florence, K.T. and M. Mbida, 2011. *In vitro* activities of acetonic extracts from leaves of three forage legumes (*Calliandra calotyrsus*, *Gliricidia sepium* and *Leucaena diversifolia*) on *Haemonchus contortus*. *Asian Pacific J. Trop. Med.*, 4: 125–128

Fouche, G., M. Ramafuthula, V. Maselela, M. Mokoena, J. Senabe, T. Leboho, B.M. Sakong, O.T. Adenubi, J.N. Eloff and K.W. Wellington, 2016a. Acaricidal activity of the organic extracts of thirteen South African plants against *Rhipicephalus* (Boophilus) *decoloratus* (Acari: Ixodidae). *Vet. Parasitol.*, 224: 39–43

Fouche, G., B. sakong, O. adenubi, E. Pauw, T. Leboho, K. Wellington and J. Eloff, 2016b. Anthelmintic activity of acetone extracts from South African plants used on egg hatching of *Haemonchus contortus*. *Onderstepoort J. Vet. Res.*, 83: e1–7

Gabr, H.S., 2012. Feeding effects of *Rhipicephalus sanguineus* (Latreille, 1806) (Acari: Ixodidae), on protein consumption and blood loss of their hosts. *J. Egypt. Soc. Parasitol*., 42: 721–726

Gadzhiev, Y.G. and R.S. Eminove, 1986a. Action of medicinal plants on gastrointestinal nematodes in sheep. Byulleten Vesesoyuznogo Instituta Gel, mintologii im. K.I. *Skryabina*, 44: 12–16

Gadzhiev, Y.G. and R.S. Eminove, 1986b. *Heracleum sosnoskyi* in the control of ovine strongylosis. *Vet. Moscow*, 6: 43–46

Gangwar, M., V.C. Verma, T.D. Singh, S.K. Singh, R.K. Goel and G. Nath, 2013. *In vitro* scolicidal activity of *Mallotus philippinensis* (Lam.) Muell Arg. fruit glandular hair extract against hydatid cyst *Echinococcus granulosus*. *Asian Pac. J. Trop. Dis.*, 6: 595–601

Gathuma, J.M., J.M. Mbaria, J. Wanyama, H.F.A. Kaburia, L. Mpoke, J.N. Mwangi, Samburu and T. Healers, 2004. Efficacy of *Myrsine africana*, *Albizia anthelmintica* and *Hilderbrantia sepa-losa* herbal remedies against mixed natural sheep helminthosis in Samburu district, Kenya. *J. Ethnopharmacol*., 91: 7–12

Getachew, S., N. Ibrahim, B. Abebe and T. Eguale, 2012. *In vitro* evaluation of Anthelmintic activities of crude extracts of selected medicinal plants against *Haemonchus contortus* in Alemgena Wereda, Ethiopia. *Acta. Parasitol. Globalis*, 3: 20–27

Geurden, T., C. Chartier, J. Fanke, A.F. Di Regalbono, D. Traversa, G. Von Samson-Himmelstjerna, J. Demeler, H.B. Vanimisetti, D.J. Bartram and M.J. Denwood, 2015. Anthelmintic resistance to ivermectin and moxidectin in gastrointestinal nematodes of cattle in Europe. *Int. J. Parasitol.,* 5: 163–171

Githiori, J.B., J. Höglund, P.J. Waller and R.L. Baker, 2002. Anthelmintic activity of preparations derived from *Myrsine africana* and *Rapanea melanophloeos* against the nematode parasite, *Haemonchus contortus*, of sheep. *J. Ethnopharmacol*., 80:187–191

Ghosh, S., A.K. Sharma, S. Kumar, S.S. Tiwari, S. Rastogi, S.S. Mahima Singh, 2011. *In vitro* and *in vivo* efficacy of *Acorus calamus* extract against Rhipicephalus (Boophilus) microplus. *Parasitol. Res*., 2: 361–370

Ghosh, S., S.S. Tiwari, S. Srivastava, A.K. Sharma, S. Kumar, D.D. Ray and A.K.S. Rawat, 2013. Acaricidal properties of *Ricinus communis* leaf extracts against organophosphate and pyrethroids resistant *Rhipicephalus* (Boophilus) *microplus*. *Vet. Parasitol.,* 192: 259–267

Ghosh, S., S.S. Tiwari, S. Srivastava, S. Kumar, A.K. Sharma, G. Nagar, K.G. Kumar, R. Kumar and A.K. Rawat, 2015a. *In vitro* acaricidal properties of *Semecarpus anacardium* fruit and *Datura stramonium* leaf extracts against acaricide susceptible (IVRI-I line) and resistant (IVRI-V line) *Rhipicephalus microplus* (Boophilus). *Res. Vet. Sci.*, 101: 69–74

Ghosh, S., T.S. Tiwari, K. Shashi, S. Bhanu, S.K. Srivastava, K. Anil, A. Sachin, J. Bandyopadhyay, S. Julliet, R. Kumar and A.K.S. Rawat, 2015b. Identification of potential plant extracts for anti-tick activity against acaricide resistant cattle ticks, *Rhipicephalus* (Boophilus) *microplus* (Acari: Ixodidae). *Exper. Appli. Acarol*., 66(1):159–171

Githiori, J.B., J. Ho ̈glund, P.J. Waller and R.L. Baker, 2003. The anthelmintic efficacy of the plant, *Albizia anthelmintica*, against the nematode parasites *Haemonchus contortus* of sheep and *Heligmosomoides polygyrus* of mice. *Vet. Parasitol*., 116: 23–34

Godara, R., S. Parveen, R.A. Katoch, P.K. Yadav, M. Verma, D. Katoch, A. Kaur, P. Ganai, N. Raghuvanshi and K. Singh, 2014. Acaricidal activity of extract of *Artemisia absinthium* against *Rhipicephalus sanguineus* of dogs. *Parasitol. Res.*, 113: 747–754

Godfrey, E.R. and S.E. Randolph, 2011. Economic downturn results in tick-borne disease upsurge. *Para. Vect.*, 4: 35

Gomes, L.V., W.D. Lopes, W.F. Teixeira, W.G. Maciel, B.C. Cruz, G. Felippelli, C. Buzzulini, V.E. Soares, D.P. De Melo, M.A. Bichuette, G. Goncalves Junior and J. Da Costa, 2016. Population dynamics and evaluation of the partial selective treatment of crossbreed steers naturally infested with *Rhipicephalus* (Boophilus) *microplus* in a herd from the state of Minas Gerais in Brazil. *Vet. Parasitol.*, 220: 72–76

Gowda, S.K., 1997. Biological effects of neem (*Azadirachta indica*) derivatives in animals. *In*: *Ethnoveterinary Medicine: Alternatives for Livestock Development*. Vol. 2. Abst. Proc. Intl. Conf. Pune, India, Nov., 4–6, 1997

Grade, J.T, B.L. Arbie, R.B. Weladji and P. Van Damme. 2008. Anthelmintic efficacy and dose determination of *Albizia anthelmintica* against gastrointestinal nematodes in naturally infected Ugandan sheep. *Vet. Parasitol*., 157: 267–274

Grzybek, M., W. Kukula-Koch and A. Strachecka, 2016. Evaluation of Anthelmintic activity and composition of pumpkin (*Cucurbita pepo* L.) seed extracts—*in vitro* and *in vivo* studies. *Int. J. Mol. Sci.,* 17: 1456

Guneidy, R.A., Y.E. Shahein, A.M. Abouelella, E.R. Zaki and R.R. Hamed, 2014. Inhibition of the recombinant cattle tick *Rhipicephalus* (Boophilus) *annulatus* glutathione S-transferase. *Ticks. Tick-borne. Dis.*, 5: 528–536

Habibi, H., S. Firouzi, H. Nili, M. Razavi, S.L. Asadi and S. Daneshi, 2016. Anticoccidial effects of herbal extracts on *Eimeria tenella* infection in broiler chickens: *in vitro* and *in vivo* study. *J. Para. Dis.,* 40: 401–407

Hamad, K.K., Z. Iqbal and G. Muhammad, 2013. Antinematicidal activity of *Nicotiana tabacum* L. leaf extracts to control benzimidazole-resistant *Haemonchus contortus* in sheep. *Pak. Vet. J.*, 33: 85–90

Handule, I.M., C. Ketavan and G. Solomon, 2002. Toxic effect of Ethiopian neem oil on larvae of cattle tick, *Rhipicephalus pulchellus* Gerstaeker. *Kasetsart J. Nat. Sci.*, 36: 18–22

Heath, A. and G.W. Levot, 2015. Parasiticide resistance in flies, lice and ticks in New Zealand and Australia: Mechanisms, prevalence and prevention. *N.Z. Vet. J.*, 63: 199–210

Hördegen, P., J. Cabaret, H. Hertzberg, W. Langhans and V. Maurer, 2006. *In vitro* screening of six anthelmintic plant products against larval *Haemonchus contortus* with a modified methyl-thiazolyl-tetrazolium reduction assay. *J. Ethnopharmacol.*, 108: 85–89

Hounzangbe, A., F.E., Zinsou, V. Hounpke, K. Moutairou and H. Hoste, 2005. *In vivo* effects of Fagara leaves on sheep infected with gastrointestinal nematodes. *Trop. Anim. Health. Prod.*, 37: 205–214

Hussain, A., M.N. Khan, M.S. Sajid, Z. Iqbal, M.K. Khan, R.Z. Abbas and G.R. Needham, 2010. *In vitro* screening of the leaves of *Musa paradisiaca* for anthelmintic activity. *J. Anim. Plant Sci.*, 20: 5–8

Hussain, A., M.N. Khan, Z. Iqbal, M.S. Sajid and M.K. Khan, 2011. Anthelmintic activity of *Trianthema portulacastrum* L. and *Musa paradisiaca* L. against gastrointestinal nematodes of sheep. *Vet. Parasitol*., 179: 92–99

Hussain, M.S., S. Fareed, S. Ansari, M.A. Rahman, I.Z. Ahmad and M. Saeed, 2012. Current approaches toward production of secondary plant metabolites. *J. Pharm. Bioallied Sci*., 4: 10

Idris, A.A., S.E.I. Adam and G. Tartour, 1982. The anthelmintic efficacy of Artemisia herba-alba against *Haemonchus contortus* infection in goats. *Nat. Inst. Anim. Hlth. Quart.*, 22: 138–143

Ilham, M.O., A.A.A. Razzig, M.T. Elhaj and Y.O. Mohammed, 2014. Acaricidal Activity of Crude Extract of *Annona Squamosa* against *Hyalomma anatolicum* (Ixodoidea: Ixodidae). *Altern. Integr. Med.*, 3: 173–177

Iqbal, Z., M. Lateef and M. Ashraf, A. Jabbar, 2004. Anthelmintic activity of *Artemisia brevifolia* in sheep. *J. Ethnopharmacol*., 93: 265–268

Iqbal, Z., M. Lateef, A. Jabbar and A.H. Gilani, 2010. *In vivo* anthelmintic activity of *Azadirachta indica* A. Juss seeds against gastrointestinal nematodes of sheep. *Vet. Parasitol*., 168: 342–345

Iqbal, Z., M. Lateef, A. Jabbar, G. Muhammad and M.N. Khan, 2005. Anthelmintic activity of *Calotropris procera* (Ait.) Ait. F. flowers in sheep. *J. Ethnopharmacol*., 102: 256–261

Iqbal, Z., M. Lateef, A. Jabbar, M.S. Akhtar and M.N. Khan, 2006. Anthelmintic Activity of *Vernonia anthelmintica* (L.) Willd. Seeds against Trichostrongylid Nematodes of Sheep. *Pharm. Biol.,* 44: 563–567

Iqbal, Z., Q.K. Nadeem, M.N. Khan, M.S. Akhtar and F.N. Waraich, 2001. *In vitro* anthelmintic Activity of *Allium sativum, Zingiber officinale, Curcurbita mexicana* and *Ficus religiosa*. *Int. J. Agric. Biol.,* 3: 454–457

Irum, S., H. Ahmed, M. Mukhtar, M. Mushtaq, B. Mirza, K. D. Łysoniewska, M. Qayyum and S. Simsek, 2015. Anthelmintic activity of Artemisia vestita Wall ex DC. and *Artemisia maritima* L. against *Haemonchus contortus* from sheep. *Vet. Parasitol.,* 212: 451–455

ITDG and IIRR, 1996. *Ethno-veterinary Medicine in Kenya: A Field Manual of Traditional Animal Health Care Practices*. Nairobi, Intermed. Technol. Devel. Group and International Institute of Rural Reconstruction

Jabbar, A., M.A. Zaman, Z. Iqbal, M. Yaseen and A. Shamim, 2007. Anthelmintic activity of *Chenopodium album* (L.) and *Caesalpinia crista* (L.) against trichostrongylid nematodes of sheep. *J. Ethnopharmacol.,* 114: 86–91

Jabbar, A., T. Abbas, Z.U. Sindhu, H.A. Saddiqi, M.F. Qamar and R.B. Gasser, 2015. Tick-borne diseases of bovines in Pakistan: Major scope for future research and improved control. *Para. Vect.*, 8: 283–296

Jabbar, A., Z. Iqbal and M.N. Khan, 2006. *In vitro* anthelmintic activity of *Trachyspermum ammi* seeds. *Pharmacol. Mag.*, 2: 126–129

Jamra, N., G. Das, P. Singh and M. Haque, 2015. Anthelmintic efficacy of crude neem (*Azadirachta indica*) leaf powder against bovine strongylosis. *J. Parasit. Dis.*, 39: 786–788

Jeyathilakan, N., K. Murali, A. Anandaraj, B.R. Latha and B.S. Abdul, 2010. Anthelmintic activity of essential oils of *Cymbopogon nardus* and *Azadirachta indica* on *Fasciola gigantica*. *J. Vet. Anim. Sci.*, 6: 204–209

Kaaya, G.P., E.N. Mwangi and M.M. Malonza, 1995. Acaricidal activity of *Margaritaria discoidea* (Euphorbiaceae) plant extracts against the ticks *Rhipicephalus appendiculatus* and *Amblyomma variegatum* (Ixodidae). *Int. J. Acarol.*, 21: 123–129

Kamaraj, C., A.A. Rahuman, G. Elango, A. Bagavan and A.A. Zahir, 2011. Anthelmintic activity of botanical extracts against sheep gastrointestinal nematodes, *Haemonchus contortus*. *Parasitol. Res.*, 109: 37–45

Kanojiya, D., D. Shanker, V. Sudan, A.K. Jaiswal and R. Parashar, 2015. In vitro and in vivo efficacy of extracts of leaves of *Eucalyptus globulus* on ovine gastrointestinal nematodes. *Parasitol. Res*.,114:141–148

Katoch, R., A. Yadav, R. Godara, J.K. Khajuria, S. Borkataki and S.S. Sodhi, 2012. Prevalence and impact of gastrointestinal helminths on body weight gain in backyard chickens in subtropical and humid zone of Jammu. *Ind. J. Para. Dis.*, 36: 49–52

Kaushik, R.K., J.C. Katiyar and A.B. Sen, 1981. A new *in vitro* screening technique for anthelmintic activity using *Ascaridia galli* as a test parasite. *Ind. J. Anim. Sci.*, 51: 869–872

Ketzis, J.K., A. Taylor, D.D. Bowman, D.L. Brown, L.D. Warnick and H.N. Erb, 2002. *Chenopodium ambrosioides* and its essential oil as treatments for *Haemonchus contortus* and mixed adult-nematode infections in goats. *Small Rumin. Res.*, 44: 193–200

Khan, M.N., A. Hussain, Z. Iqbal, M.K. Khan and M.S. Sajid, 2010a. Evaluation of anthelmintic activity of *Lagenaria siceraria* (Molina) Standl and *Albizia lebbeck* L. against gastrointestinal helminths of sheep. *Egypt. J. Sheep Goat Sci*., 5: 307–321

Khan, M.N., M.S. Sajid, M.K. Khan, Z. Iqbal and A. Hussain, 2010b. Gastrointestinal helminthiasis: prevalence and associated determinants in domestic ruminants of district Toba Tek Singh, Punjab, Pakistan. *Parasitol. Res.*, 107: 787–794

Khan, S., K. Afshan, B. Mirza, J.E. Miller, A. Manan, S. Irum, S.S. Rizvi and M. Qayyum, 2015. Anthelmintic properties of extracts from Artemisia plants against nematodes. *Trop. Biomed.*, 32: 257–268

Kmieciak, W., M. Ciszewski and E.M. Szewczyk, 2016. Tick-borne diseases in Poland: Prevalence and difficulties in diagnostics. *Medycyna Pracy*., 67: 73–87

Kongkiatpaiboon, S., V. Pattarajinda, V. Keeratinijakal and W. Gritsanapan, 2014. Effect of Stemona spp. against *Rhipicephalus microplus*. *Exp. Appl. Acarol.*, 62: 115–120

Kumar, A. and S. Partap, 2015. *In Vitro* Anthelmintic Activity of *Lagenaria siceraria* Leaves in Indian Adult Earthworm. *J. Pharmacog. Phytochemist.*, 4: 39–42

Kumar, K.G., A.B. Tayade, R. Kumar, S. Gupta, A.K. Sharma, G. Nagar, S.S. Tewari, B. Kumar, A.K. Rawat, S. Srivastava, S. Kumar and S. Ghosh, 2016. Chemo-profiling and bioassay of phytoextracts from *Ageratum conyzoides* for acaricidal properties against *Rhipicephalus* (Boophilus) *microplus* (Acari: Ixodidae) infesting cattle and buffaloes in India. *Ticks. Tick-borne Dis.*, 7: 342–349

Kumarasinghe, R., S. Preston, T.C. Yeo, D.S.L. Lim, C.L. Tu, E.A. Palombo and P.R. Boag, 2016. Anthelmintic activity of selected ethno-medicinal plant extracts on parasitic stages of *Haemonchus contortus*. *Para. Vect.*, 9: 187–191

Lashari, M.H., Z. Tasawar, M.S. Akhtar, M.S. Chaudhary and N. Sial, 2015. Prevalence of *Haemonchus contortus* in local goat's of DG Khan." *World. J. Pharm. Pharmaceut. Sci.*, 4: 190–196

Lateef, M., Z. Iqbal, U. Rauf and A. Jabbar, 2006a. Anthelmintic activity of *Carum copticum* seeds against gastro-intestinal nematodes of sheep. *J. Anim. Plant Sci.*, 16: 34–37

Lateef, M., Z. Iqbal, M.S. Akhtar, A. Jabbar, M.N. Khan and A.H. Gilani, 2006b. In vivo anthelmintic activity of Butea monosperma against trichostrohylid nematodes in sheep. *Fitoterpia*, 77: 137–140

Liaqat, I., Q. Pervaiz, S.J. Bukhsh, S.I. Ahmed and N. Jahan, 2016. Investigation of bactericidal effects of medicinal plant extracts on clinical isolates and monitoring their biofilm forming potential. *Pak. Vet. J.*, 36: 159–164

Lone, B.A., M.Z. Chishti, F.A. Bhat, H. Tak and S.A. Bandh, 2012. *In vitro* and *in vivo* anthelmintic activity of *Euphorbia helioscopia* L. *Vet. Parasitol.*, 189: 317–321

Lone, B.A., S.A. Bandh, M.Z. Chishti, F.A. Bhat, H. Tak and H. Nisa, 2013. Anthelmintic and antimicrobial activity of methanolic and aqueous extracts of *Euphorbia helioscopia* L. *Trop. Anim. Health Prod.*, 45: 743–749

Lwande, W., A.J. Ndakala, A. Hassanali, L. Moreka, E. Nyandat, M. Ndungu, H. Amiani, P.M. Gitu, M.M. Malonza and D.K. Punyua, 1999. *Gynandropsis gynandra* essential oil and its constituents as tick (*Rhipicephalus appendiculatus*) repellents. *Phytochem.*, 50: 401–405

MacDonald, D., K. VanCrey, P. Harrison, P.K. Rangachari, J. Rosenfeld, C. Warren and G. Sorger, 2004. Ascaridole-less infusions of *Chenopodium ambrosioides* contain a nematocide(s) that is (are) not toxic to mammalian smooth muscle. *J. Ethnopharmacol.*, 92: 215–221

Magona, J.W., J. Walubengo, W. Olaho-Mukani, N.N. Jonsson, S.W. Welburn and M.C. Eisler, 2011. Spatial variation of tick abundance and seroconversion rates of indigenous cattle to *Anaplasma marginale*, *Babesia bigemina* and *Theileria parva* infections in Uganda. *Exp. Appl. Acarol*., 55: 203–213

Maharaj, S., A. Mutani and V. Simmons, 2005. Preliminary bioassay of neem (*Azadirachta indica*) bark extract as a phytoacaricide against test species *Boophilus microplus*. *West Ind. Vet. J.*, 5: 16–18

Malonza, M.M., 1992. Laboratory and field observations on antitick properties of the plant *Gynandropsis gynandra* (L) Brig. *Vet. Parasitol.*, 42: 123–136

Maphosa, V. and P.J. Masika, 2012. *In vivo* validation of *Aloe ferox* (Mill). *Elephantorrhiza elephantina* Bruch. Skeels and *Leonotis leonurus* (L) R. BR as potential anthelminthics and antiprotozoals against mixed infections of gastrointestinal nematodes in goats. *Parasitol. Res.*, 110: 103–108

Maphosa, V., P.J. Masika, E.S. Bizimenyera and J.N. Eloff, 2010. *In-vitro* anthelminthic activity of crude aqueous extracts of *Aloe ferox*, *Leonotis leonurus* and *Elephantorrhiza elephantina* against *Haemonchus contortus*. *Trop. Anim. Hlth. Prod*., 42: 301–307

Marie-Magdeleine, C., L. Udino, L. Philibert, B. Bocage and H. Archimede, 2014. *In vitro* effects of *Musa* x *paradisiaca* extracts on four developmental stages of *Haemonchus contortus*. *Res. Vet. Sci.*, 96: 127–132

Maroyi, A., 2012. Use of traditional veterinary medicine in Nhema communal area of the Midlands province, Zimbabwe. *Afr. J. Tradit. Complem. Alterna. Med*., 9: 315–322

Martinez-Ortiz-de-Montellano, C., C. Arroyo-Lopez, I. Fourquaux, J.F. Torres-Acosta, C.A. Sandoval-Castro and H. Hoste, 2013. Scanning electron microscopy of *Haemonchus contortus* exposed to tannin-rich plants under *in vivo* and *in vitro* conditions. *Exp. Parasitol.*, 133: 281–286

Martinez-Velazquez, M., G.A. Castillo-Herrera, R. Rosario-Cruz, J.M. Flores-Fernandez, J. Lopez-Ramirez, R. Hernandez-Gutierrez and C. Lugo-Cervantes Edel, 2011. Acaricidal effect and chemical composition of essential oils extracted from *Cuminum cyminum*, *Pimenta dioica* and *Ocimum basilicum* against the cattle tick *Rhipicephalus* (Boophilus) *microplus* (Acari: Ixodidae). *Parasitol. Res.*, 108: 481–487

Matias, R., S. Solon, U.M. Resende, A. Gomes, M. Maganha, G.D.S. Pereira, P. Nozu and W.W. Koller, 2003. Chemical-pharmacological study of the *Melia azedarach* (Meliaceae) on Boophilus. *Ensaios e Ciencia: Serie Ciencias Biol. Agrarias, Saude,* 7: 283–293

Matsabisa, M.G., W.E. Campbell, P.I. Folb and P.J. Smith, 2013. *Treatment of Parasitic Infections in Humans and Animals.* 2006. (WO/2006/048734). U.S. Patent 8,586,112, November 19, 2013

Mbaya, A.W. and M. Ogwiji, 2014. *In vivo* and *in vitro* activities of medicinal plants on ecto, endo and haemoparasitic infections: a review. *Curr. Clin. Pharmacol.,* 9: 271–282

McTier, T.L., R.H. Six, J.J. Fourie, A. Pullins, L. Hedges, S.P. Mahabir and M.R. Myers, 2016. Determination of the effective dose of a novel oral formulation of sarolaner (Simparica) for the treatment and month-long control of fleas and ticks on dogs. *Vet. Parasitol.*, 222: 12–17

Meenakshisundaram, A., T.J. Harikrishnan and T. Anna, 2016. Anthelmintic activity of *Indigofera tinctoria* against gastrointestinal nematodes of sheep. *Vet. World,* 9: 101–106

Mehlhorn, H., G. Schmahl and J. Schmidt, 2005. Extract of the seeds of the plant Vitex agnus castus proven to be highly efficacious as a repellent against ticks, fleas, mosquitoes and biting flies. *Parasitol. Res.,* 95: 363–365

Minja, M.M.J., 1989. Collection of Tanzanian medicinal plants for biological activity studies. *In*: *Proc. 7th Tanzania Vet. Assoc. Sci. Conf., Arusha*, 7: 67–78

Mishra, C.K., D. Sasmal and B. Shrivastava, 2012. An in vitro evaluation of the anthelmintic activity of unripe fruits extract of *Carissa carandas* Linn. *Int. J. Drug Dev. Res.,* 4: 393–397

Mithöfer, A. and W. Boland, 2012. Plant defense against herbivores: chemical aspects. *Annu. Rev. Plant Biol.,* 63: 431–450

Mondal, D.B., K. Sarma and M. Saravanan, 2013. Upcoming of the integrated tick control program of ruminants with special emphasis on livestock farming system in India. *Ticks tick-borne Dis*., 4: 1–10

Mondal, H., H. Hossain, K. Awang, S. Saha, S.M.U. Rashid, M.K. Islam, M.S. Rahman, I.A. Jahan, M.M. Rahman and J.A. Shilpi, 2015. Anthelmintic activity of ellagic acid, a major constituent of *Alternanthera sessilis* against *Haemonchus contortus*. Pak. Vet. J., 35: 58–62

Morais-Costa, F., A.C.M. Soares, G.A. Bastos, Y.R.F. Nunes, L.C. Geraseev, F.C. Braga and E.R. Duarte, 2015. Plants of the Cerrado naturally selected by grazing sheep may have potential for inhibiting development of *Haemonchus contortus* larva. *Tropic. Anim. Health Production,* 47: 1321–1328

Mostofa, M., Q.A. McKellar, M.N. Alam, L.F. Le-Jambre and M.R. Know, 1996. Epidemiology of gastrointestinal helminth parasites in small ruminants in Bangladesh and their anthelmintic therapy. *Sustainable parasite control in small ruminants: Int. workshop sponsored by ACIAR and held in Bogor, Indonesia*, pp: 105–108. 22–25 April, 1996

Muniz-Lagunes, A., R. Gonzalez-Garduno, M.E. Lopez-Arellano, R. Ramirez-Valverde, A. Ruiz-Flores, G. Garcia-Muniz, G. Ramirez-Vargas, P. Mendoza-de Gives and G. Torres-Hernandez, 2015. Anthelmintic resistance in gastrointestinal nematodes from grazing beef cattle in Campeche State, Mexico. *Trop. Anim. Health. Prod.*, 47: 1049–1054

Muro, C.F., C. Cruz-Vazquez, M. Fernandez-Ruvalcaba, J. Molina-Torres, C.J. Soria and P.M. Ramos, 2003. Repellence of *Boophilus microplus* larvae in *Stylosanthes humilis* and *Stylosanthes hamata* plants. *Parasitologia Latinoamericana*, 58: 118–121

Muro, C.F.J., C. Cruz-Vazquez, M. Fernandez-Ruvalcaba and T.J. Molina, 2004. Repellent effect of *Melinis minutiflora* extract on *Boophilus microplus* tick larvae. *Veterinaria Mexico*, 35: 153–159

Murti, Y., S. Sharma and P. Mishra, 2015. *In vitro* anthelminthic activity of calotropis procera (AIT.) R. BR. leaves. *Asian J. Pharm. Clin. Res.,* 8: 188–190

Muyobela, J., P.O. Nkunika and E.T. Mwase, 2015. Resistance status of ticks (Acari; Ixodidae) to amitraz and cypermethrin acaricides in Isoka District, Zambia. *Trop. Anim. Health. Prod.*, 47: 1599–1605

Mwangi, E.N., A. Hassanali, S. Essuman, E. Myandat, L. Moreka and M. Kimondo, 1995. Repellent and acaricidal properties of *Ocimum suave* against *Rhipicephalus appendiculatus* ticks. *Exp. Appl. Acarol.,* 19: 11–18

Nawaz, M., S.M. Sajid, A. Zulfiqar, W. Muhammad, A. Tanveer, H. Abid, M. Abrar, S. Asim, Z. Muhammad and K. Imran, 2015. Anti-Tick Activity of Leaves of *Azadirachta indica*, *Dalbergia sisso* and *Morus alba* against *Rhipicephalus microplus*. *Acta Parasitol. Glob*., 6: 60–64

Nayak, D.P., P.K. Swain, O.P. Panda, P. Pattanaik and B. Srinivas, 2010. Antimicrobial and anthelmintic evalution of *Chenopodium album*. *Int. J. Pharma. World Res.,* 4: 201–215

Ndungu, M.W., S.C. Chhabra and W.L. Wande, 1999. Cleome hirta essential oil as livestock tick (*Rhipicephalus appendiculatus*) and maize weevil (*Sitophilus zeamais*) repellent. *Fitoterapia*, 70: 514–516

Neergheen-Bhujun, V.S., 2013. Underestimating the toxicological challenges associated with the use of herbal medicinal products in developing countries. *BioMed. Res. Int*., 804086

Nosal, P., M. Murawski, P. Bartlewski, J. Kowal and M. Skalska, 2016. Assessing the usefulness of mineral licks containing herbal extracts with anti-parasitic properties for the control of gastrointestinal helminths in grazing sheep–A field trial. *Helminthol*., 53: 180–185

Nwude, N. and M.A. Ibrahim, 1980. Plants used in traditional veterinary medical practice in Nigeria. *J. Vet. Pharmacol. Therap*., 3: 261–273

Nyahangare, E.T., B.M. Mvumi and T. Mutibvu, 2015. Ethnoveterinary plants and practices used for ecto-parasite control in semi-arid smallholder farming areas of Zimbabwe. *J. Ethnobiol. Ethnomed.*, 11: 30

Opara, M.N., A. Santali, B.R. Mohammed and O.C. Jegede, 2016. Prevalence of Haemoparasites of Small Ruminants in Lafia Nassarawa State: A Guinea Savannah Zone of Nigeria. *J. Vet. Adv.,* 6: 1251–1257

Orr, C., 2015. *Comparing Alternatives for Controlling Internal Parasites in Dairy Goats: Herbal vs. Chemical*. 2015. https://fiascofarm.com/goats/herbalwormer.htm. (Accessed 30 June 2015)

Pal, D., T.K. Mohapatra and A. Das, 2008. Evaluation of anthelmintic activity of nuts of *Semecarpus anacardium*. *Ancient Sci. Life*, 3: 41–44

Pamo, E.T., F. Tendonkeng, J.R. Kana, V.K. Payne, B. Boukila, J. Lemoufouet, E. Miegoue and A.S. Nanda, 2005. A study of the acaricidal properties of an essential oil extracted from the leaves of *Ageratum houstonianum*. *Vet. Parasitol*., 128: 319–323

Parveen, S., R. Godara and R. Katoch, 2014. *In Vitro* evaluation of ethanolic extracts of *Ageratum conyzoides* and *Artemisia absinthium* against cattle tick, *Rhipicephalus microplus*. *Sci. World J.*, 2014: Article ID 858973

Patel, U.D., H.B. Patel and T.M. Shah, 2013. *Drug Resistance: An Emerging Threat*. Training on "Recent trends in diagnosis and control of emerging diseases of livestock", 48

Pathak, D., V.C. Mathur, B.R. Latha and L. John, 2004. *In vitro* effect of indigenous plant extracts on ixodid ticks of small ruminants. *Ind. J. Anim. Sci*., 74: 616–617

Peachey, L.E., G.L. Pinchbeck, J.B. Matthews, F.A. Burden, G. Mulugeta, C.E. Scantlebury and J.E. Hodgkinson, 2015. An evidence-based approach to the evaluation of ethnoveterinary medicines against strongyle nematodes of equids. *Vet. Parasitol*., 210: 40–52

Pereira, J.R. and K.M. Famadas, 2006. The efficiency of extracts of *Dahlstedtia pentaphylla* (Leguminosae, Papilionoidae, Millettiedae) on *Boophilus microplus* (Canestrini, 1887) in artificially infested bovines. *Vet. Parasitol*., 142: 192–195

Pirali-Kheirabadi, K. and M. Razzaghi-Abyaneh, 2007. Biological activities of chamomile (*Matricaria chamomile*) flowers' extract against the survival and egg laying of the cattle fever tick (*Acari Ixodidae*). *J. Zhejiang. Univ. Sci.*, 8: 693–696

Playford, M.C., A.N. Smith, S. Love, R.B. Besier, P. Kluver and J.N. Bailey, 2014. Prevalence and severity of anthelmintic resistance in ovine gastrointestinal nematodes in Australia (2009-2012). Australian. *Vet. J.,* 92: 464–471

Pustovoi, I.F., 1968. The anthelmintic properties of of plants from the pausture of Tadzhikistan. *Izvestiya Akademii Nauk Tadzhikskoi SSR Ahboroti Akademi jai Fanhoi RSS Tocikiston, Otdelenie Biologicheskikh Nauk.*, 3: 13–17

Qamar, M.F., A. Maqbool, M.S. Khan, N. Ahmad and M.A. Muneer, 2011. Epidemiology of Haemonchosis in sheep and goats under different managemental conditions. *Vet. World*, 2: 413–417

Radhakrishnan, L., S. Gomathinayagam and V. Balakrishnan, 2007. Evaluation of anthelmin effect of Neem (*Azadirachta indica*) leaves on *Haemonchus contortus* in goats. *Res. J. Parasitol.*, 2: 57–62

Ramos, F., L.P. Portella, S. Rodrigues Fde, C.Z. Reginato, L. Potter, A.S. Cezar. L.A. Sangion and F.S. Vogel, 2016. Anthelmintic resistance in gastrointestinal nematodes of beef cattle in the state of Rio Grande do Sul, Brazil. *Int. J. Parasitol*., 6: 93–101

Rashid, M.M., J. Ferdous, S. Banik, M.R. Islam, A.H. Uddin and F.N. Robel, 2016. Anthelmintic activity of silver-extract nanoparticles synthesized from the combination of silver nanoparticles and *Momordica charantia* fruit extract. *BMC Complement Altern. Med*., 16: 242

Rattan, R.S., 2010. Mechanism of action of insecticidal secondary metabolites of plant origin. *Crop Protec.*, 29: 913–920

Ravinet, N., C. Chartier, N. Bareille, A. Lehebel, A. Ponnau, N, Brisseau and A. Chauvin, 2016. Unexpected decrease in milk production after fenbendazole treatment of dairy cows during early grazing season. *PLoS One*, 11: e0147835

Raza, M.A., M. Younas and E. Schlecht, 2016. *In vitro* efficacy of selected medicinal plants from Cholistan desert, Pakistan, against gastrointestinal helminths of sheep and goats. *J. Agric. Rural Dev.Trop. Subtrop.*, 117: 211–224

Ribeiro, V.L., V. Rolim, S. Bordignon, A.T. Henriques, G.G. Dorneles, R.P. Limberger and G. von Poser, 2008. Chemical composition and larvicidal properties of the essential oils from *Drimys brasiliensis* Miers (Winteraceae) on the cattle tick *Rhipicephalus* (Boophilus) *microplus* and the brown dog tick *Rhipicephalus sanguineus*. *Parasitol. Res.*, 102: 531–535

Ribeiro, V.L.S., E. Toigo, S.A.L. Bordignon, K. Goncalves and G.V. Poser, 2007. Properties of extracts from the aerial parts of *Hypericum polyanthemum* on the cattle tick *Boophilus microplus*. *Vet. Parasitol.*, 147: 199–203

Roeber, F., A.R. Jex and R.B. Gasser, 2013. Impact of gastrointestinal parasitic nematodes of sheep, and the role of advanced molecular tools for exploring epidemiology and drug resistance - an Australian perspective. *Parasites Vectors*, 6: 153

Rowe, A., K. McMaster, D. Emery and N. Sangster, 2008. Haemonchus contortus infection in sheep: parasite fecundity correlates with worm size and host lymphocyte counts. *Vet Parasitol*., 153: 285–93

Salifou, S., D.F. Daga, S. Attindehou, R. Deguenon and C.F. Biaou, 2013. Antiparasitic effects of the water extract from *Chenopodium ambrosioides* L. (Chenopodiaceae) against some gastrointestinal nematodes in West African Long Legged goats. *J. Parasitol Vec. Biol.*, 5: 13–16

Salles, H.O., A.C.L. Braga, M.T.D.S. do Nascimento, A.M.P. Sousa, A.R. Lima, L.D.S. Vieira, A.C.R. Cavalcante, A.S. do Egito and L.B.D.S. Andrade, 2014. Lectin, hemolysin and protease inhibitors in seed fractions with ovicidal activity against *Haemonchus contortus*. *Revista Brasileira de Parasitologia Veterinária*, 23: 136–143

Savithramma, N., M.L. Rao and D. Suhrulatha, 2011. Screening of medicinal plants for secondary metabolites. *Middle-East J. Sci. Res.*, 8: 579–584

Scala, A., A.P. Pipia, F. Dore, G. Sanna, C. Tamponi, R. Marrosu, E. Bandino, C. Carmona, B. Boufana and A. Varcasia, 2015. Epidemiological updates and economic losses due to *Taenia hydatigena* in sheep from Sardinia, Italy. *Parasitol. Res.*, 114: 3137–3143

Seddiek, S.A., M.M. Ali, H.F. Khater and M.M. El-Shorbagy, 2011. Anthelmintic activity of the white wormwood, *Artemisia herba-alba* against *Heterakis gallinarum* infecting turkey poults. *J. Med. Plants Res.*, 5: 3946–3957

Shalaby, H.A., N.M.T. Abu El Ezz, T.K. Farag and H.A.A. Abou-Zeina, 2012. *In vitro* efficacy of a combination of ivermectin and *Nigella sativa* oil against helminth parasites. *Glob. Vet*., 9: 465–473

Shyma, K.P., J.P. Gupta, S. Ghosh, K.K. Patel, V. Singh, 2014. Acaricidal effect of herbal extracts against cattle tick *Rhipicephalus* (Boophilus) *microplus* using *in vitro* studies. *Parasitol. Res.*, 113: 1919–1926

Silva Fdos, S., U.P Albuquerque, L.M. Costa Junior, S. Lima Ada, A.L. do Nascimento and J.M. Monteiro, 2014. An ethnopharmacological assessment of the use of plants against parasitic diseases in humans and animals. *J. Ethnopharmacol.*, 155: 1332–1341

Sindhu, Z., N.N. Jonsson and Z. Iqbal, 2012. Syringe test (modified larval immersion test): A new bioassay for testing acaricide activity of plant extracts against *Rhipicephalus microplus*. *Vet. Parasitol.*, 188: 362–367

Sindhu, Z.U., D.Z. Iqbal, M. Asim, A. Ahmad, R.Z. Abbas and B. Aslam, 2014. *In vitro* ovicidal and wormicidal activity of six medicinal plants against *Haemonchus contortus*. *Int. J. Agric. Biol.*, 16: 1199–1203

Singh, B.B., N.K. Dhand, S. Ghatak and J.P Gill, 2014. Economic losses due to cystic echinococcosis in India: Need for urgent action to control the disease. *Preventive. Vet. Med.*, 113: 1–12

Singh, S., A.K. Pathak, R.K. Sharma and M. Khan, 2015. Effect of tanniferous leaf meal based multi-nutrient blocks on feed intake, hematological profile, immune response, and body weight changes in *Haemonchus contortus* infected goats. *Vet. World*, 5: 572–579

Solcan, C., D. Acatrinei, V. Floristean, G. Solcan, B.G. Şlencu and M Fântânariu, 2015. An unusual case of megacolon due to *Sarcocystis* spp. infection and local amyloidosis in a Husky dog. *Pak. Vet. J*., 35: 531–533

Somnath, D., P.D. Bhinge and C.S. Magdum, 2015. *In vitro* anthelmintic activity of leaf extracts of *Adhatoda vasica* Nees (Acanthaceae) against *Eudrilus eugeniae*. *J. Pharm. Sci.*, 2: 153–155

Sorge, U.S., R.D. Moon, B.E. Stromberg, S.L. Schroth, L. Michels, L.J. Wolff, D.F. Keltonand B.J. Heins, 2015. Parasites and parasite management practices of organic and conventional dairy herds in Minnesota. *J. Dairy Sci.*, 5: 3143–3151

Sousa, L.A., H.B. Pires, S.F. Soares, P.H. Ferri, P. Ribas, P.E.M. Lima, J. Furlong, V.R. Bittencourt, W.M. Perinotto and L.M. Borges, 2011. Potential synergistic effect of *Melia azedarach* fruit extract and *Beauveria bassiana* in the control of *Rhipicephalus* (Boophilus) *microplus* (Acari: Ixodidae) in cattle infestations. *Vet. Parasitol*., 175: 320–324

Swarnkar, C.P., D. Singh, F.A. Khan and P.S.K. Bhagwan, 2009. Anthelmintic potential of *Embelia ribes* seeds against *Haemonchus contortus* of sheep. *Ind. J. Anim. Sci*., 79: 167–170

Tamboli, E.T., K. Chester and S. Ahmad, 2015. Quality control aspects of herbs and botanicals in developing countries: *Coleus forskohlii* Briq a case study. *J. Pharm. Bioalli. Sci*., 7: 254–259

Tandon, V., A.K. Yadav, B. Roy and B. Das, 2011. *Phytochemicals as Cure of Worm Infections in Traditional Medicine Systems*, pp: 351–378. Emerging trends in zoology. Narendra Publishing House, New Delhi, India

Tasawar, Z., S. Ahmad, M.H. Lashari and C.S. Hayat, 2010. Prevalence of *Haemonchus contortus* in sheep at research centre for conservation of Sahiwal cattle (RCCSC) Jehangirabad District Khanewal, Punjab, Pakistan. *Pak. J. Zool.*, 42: 735–739

Taylor, M.A., K.R. Hunt and K.L. Goodyear. 2002. Anthelmintic resistance detection methods. Vet. Parasitol., 103(3): 183–194

Thakur, G.T., G.M. Chigure, P.M. Shirsikar, B.S. Khillare and A.K. Jayraw, 2007. *In vitro* trial of chemical and herbal acaricides against *Boophilus microplus* ticks. *Royal Vet. J. Ind.*, 3: 142–146

Tochi, B.N., J. Peng, S. Song, L. Liu, H. Kuan and C. Xu, 2016. Determination of sarafloxacin and its analogues in milk using an enzyme-linked immunosorbent assay based on a monoclonal antibody. *Analytical Methods*, 8: 1626–1636

Upadhyay, B., K.P. Singh and A. Kumar, 2011. Ethno-veterinary uses and informants consensus factor of medicinal plants of Sariska region, Rajasthan, India. *J. Ethnopharma*., 133: 14–25

Uppala, P.K., M. Krishna, B.K. Kumar and D.J. Ramji, 2016. Evaluation of anthelmintic activity of the chloroform and aqueous extracts of leaves of *Couroupita guianensis* on *Pheretima posthuma* by worm motility assay method. *Res. J. Pharmacol. Pharmacodyna*, 8: 118–122

Várady, M., P. Čudeková and J. Čorba, 2007. *In vitro* detection of benzimidazole resistance in *Haemonchus contortus*: egg hatch test versus larval development test. *Vet. Parasitol*., 149:104–110

Veeramani, V., S. Sakthivelkumar, K. Tamilarasan, S.O. Aisha and S. Janarthanan, 2014. Acaricidal activity of *Ocimum basilicum* and *Spilanthes acmella* against the ectoparasitic tick, *Rhipicephalus* (Boophilus) *microplus* (Arachinida: Ixodidae). *Trop. Biomed.*, 31: 414–421

Verma, A.K. and S.K. Singh, 2016. Control and therapeutic management of bovine tropical theileriosis in crossbred cattle. *J. Para. Dis*., 40: 208–210

Voigt, K., P.L. Sieber, C. Sauter-Louis, G. Knubben-Schweizer and M. Scheuerle, 2016. Prevalence of pasture-associated metazoal endoparasites in Bavarian dairy goat herds and farmers' approaches to parasite control. *Berliner und Munchener Tierarztliche Wochenschrift*., 129: 323–332 von Samson-Himmelstjerna, G., T.K. Walsh, A.A. Donnan, S. Carriere, F. Jackson, P.J. Skuce, K. Rohn and A.J. Wolstenholme, 2009. Molecular detection of benzimidazole resistance in Haemonchus contortus using real-time PCR and pyrosequencing. Parasitol. 136: 349–358

Vudriko, P., J. Okwee-Acai, D.S. Tayebwa, J. Byaruhanga, S. Kakooza, E. Wampande, R. Omara, J.B. Muhindo, R. Tweyongyere, D.O. Owiny, T. Hatta, N. Tsuji, R. Umemiya-Shirafuji, X., Xuan, M. Kanameda, K. Fujisaki and H. Suzuki, 2016. Emergence of multi-acaricide resistant *Rhipicephalus* ticks and its implication on chemical tick control in Uganda. *Para. Vect.*, 9: 4

Wadekar, J.B., P.Y. Pawar, V.V. Nimbalkar, B.S. Honde, P.R. Jadhav and S.B. Nale, 2016. Anticonvulsant, anthelmintic and antibacterial activity of *Lawsonia inermis. J. Phytopharmacol.*, 5: 53–55

Williams, A.R., J. Soelberg and A.K. Jäger, 2016. Anthelmintic properties of traditional African and Caribbean medicinal plants: identification of extracts with potent activity against *Ascaris suum in vitro*. *Parasite*, 23: 24

Worku, M., R. Franco and J.H. Miller, 2009. Evaluation of the activity of plant extracts in Boer goats. *Amer. J. Anim. Vet. Sci.*, 4: 72–79

Zahid, M.U., M.H. Hussain, M. Saqib, H. Neubauer, G. Abbas, I. Khan, M.K. Mansoor, M.N. Asi, T. Ahmad and G. Muhammad, 2016. Seroprevalence of Q fever (Coxiellosis) in small ruminants of two districts in Punjab, Pakistan. *Vect. Borne. Zoonotic. Dis.*, 16: 449–454

Zaman, M.A., Z. Iqbal, R.Z. Abbas, M.N. Khan, G. Muhammad, M. Younus and S. Ahmed, 2012a. *In vitro* and *in vivo* acaricidal activity of a herbal extract. *Vet. Parasitol.,* 186: 431–436

Zaman, M.A., Z. Iqbal, M.N. Khan and G. Muhammad, 2012b. Anthelmintic activity of a herbal formulation against gastrointestinal nematodes of sheep. *Pak. Vet. J.,* 32: 117–121

Zheng, H., Z. Yu, L. Zhou, X. Yang and J. Liu, 2012. Seasonal abundance and activity of the hard tick *Haemaphysalis longicornis* (Acari: Ixodidae) in North China. *Exp. Appl. Acarol*., 56: 133–141

(Received 09 Decmber 2016; Accepted 29 December 2016)